Claims

1. A bioactive catalytic material for providing protection against chemical agents comprising:

(a) at least one enzyme to degrade the chemical agent immobilized within at least one polyelectrolyte; and

(b) a polymerized end-capping agent.

2. The bioactive catalytic material of claim 1 additionally comprising metal chelated catalytic particles immobilized within said at least one polyelectrolyte.

3. The bioactive catalytic material of claim 2 wherein said metal chelated catalytic particles are selected from the group consisting of metal chelated (EDA-Cu^{2+}) polymer, silica particles, and combinations thereof.

4. The bioactive catalytic material of claim 1 additionally comprising adsorbent particles immobilized within said at least one polyelectrolyte.

5. The bioactive catalytic material of claim 4 wherein said adsorbent particles are functional catalytic particles made by incorporating quaternary ammonium surfactant to silica microparticles.

6. The bioactive catalytic material of claim 1 wherein the at least one enzyme is selected from the group consisting of organophosphorous hydrolase (OPH), organophosphorous acid anhydrolase (OPAA), DFPase, phosphotriesterases, and combinations thereof.

7. The bioactive catalytic material of claim 1 wherein said at least one polyelectrolyte is selected from the group consisting of branched or linear polyethyleneimine (PEI), polyacrylic acid (PAA), polystyrene sulfonate (PSS), polydiallyl dimethyl ammonium chloride (PDDA), their chemically altered derivatives, and combinations thereof.

8. The bioactive catalytic material of claim 1 wherein said end-capping agent is a readily polymerizable monomer.

9. The bioactive catalytic material of claim 1 wherein said end-capping agent is selected from the group consisting of 1,2-dihydroxypropyl methacrylate (DHPM), 1,2-

dihydroxypropyl 4-vinylbenzyl ether (DHPVB), N-[3-trimethoxysilyl)propyl]ethylenediamine (TMSED), and combinations thereof.

10. A bioactive catalytic material for providing protection against chemical agents comprising:

(a) enzyme-coated catalytic particles;

(b) metal-chelated catalytic particles;

(c) functionalized catalytic particles;

(d) polyelectrolytes to hold the enzyme-coated, metal-chelated, and functionalized catalytic particles together; and

(e) a polymerized end-capping agent.

11. The bioactive catalytic material of claim 10 wherein the enzyme-coated particles are selected from the group consisting of organophosphorous hydrolase (OPH), organophosphorous acid anhydrolase (OPAA), DFPase, phosphotriesterases, and combinations thereof.

12. The bioactive catalytic material of claim 10 wherein said metal chelated catalytic particles are selected from the group consisting of metal chelated (EDA-Cu^{2+}) polymer, silica particles, and combinations thereof.

13. The bioactive catalytic material of claim 10 wherein said functional catalytic particles are made by incorporating quaternary ammonium surfactant to silica microparticles.

14. The bioactive catalytic material of claim 10 wherein said polyelectrolytes are selected from the group consisting of branched or linear polyethyleneimine (PEI), polyacrylic acid (PAA), polystyrene sulfonate (PSS), polydiallyl dimethyl ammonium chloride (PDDA), their chemically altered derivatives, and combinations thereof.

15. The bioactive catalytic material of claim 10 wherein said end-capping agent is an readily polymerizable monomer.

16. The bioactive catalytic material of claim 10 wherein said end-capping agent is selected from the group consisting of 1,2-dihydroxypropyl methacrylate (DHPM), 1,2-dihydroxypropyl 4-vinylbenzyl ether (DHPVB), N-[3-trimethoxysilyl)propyl]ethylenediamine (TMSED), and combinations thereof.

17. A method of making a bioactive catalytic material comprising the steps of:

(a) immobilizing at least one enzyme within at least one polyelectrolyte;

(b) depositing an end-capping agent on the at least one enzyme immobilized within at least one polyelectrolyte; and

(c) polymerizing the end-capping agent.

18. The method of claim 17 additionally comprising immobilizing metal chelated catalytic particles within said at least one polyelectrolyte.

19. The method of claim 18 wherein said metal chelated catalytic particles are selected from the group consisting of metal chelated (EDA-Cu^{2+}) polymer, silica particles, and combinations thereof.

20. The method of claim 17 additionally comprising immobilizing adsorbent particles within said at least one polyelectrolyte.

21. The method of claim 20 wherein said adsorbent particles are functional catalytic particles made by incorporating quaternary ammonium surfactant to silica microparticles.

22. The method of claim 17 wherein the at least one enzyme is selected from the group consisting of organophosphorous hydrolase (OPH), organophosphorous acid anhydrolase (OPAA), DFPase, phosphotriesterases, and combinations thereof.

23. The method of claim 17 wherein said at least one polyelectrolyte is selected from the group consisting of branched or linear polyethyleneimine (PEI), polyacrylic acid (PAA), polystyrene sulfonate (PSS), polydiallyl dimethyl ammonium chloride (PDDA), their chemically altered derivatives, and combinations thereof.

24. The method of claim 17 wherein said end-capping agent is a readily polymerizable monomer.

25. The method of claim 17 wherein said end-capping agent is selected from the group consisting of 1,2-dihydroxypropyl methacrylate (DHPM), 1,2-dihydroxypropyl 4-vinylbenzyl ether (DHPVB), N-[3-trimethoxysilyl)propyl]ethylenediamine (TMSED), and combinations thereof.